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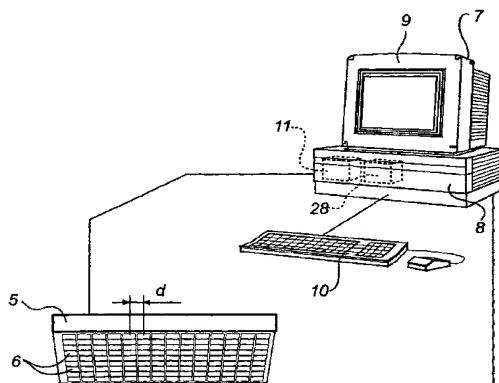
(57) Abstract: A microscope comprises an object holder (2), a display, optics (4) which in an image plane forms an image of an object (1) which is placed in the object holder (2), and an image sensor (5) for recording the image. The microscope further comprises a display (9), and an input means (10) for selecting an area in an image and a resolution in the area, a storage means and a calculation means which is connected to the image sensor. The calculation means is adapted (i) to digitally store in the storage means at least two recorded images, each of the images partly overlapping at least one other image, (ii) to join the at least two recorded images so that the composite image is an image of the area which is reproduced on the at least two recorded images, and (iii) to store in the storage means (11) information about the composite image. The calculation means is further adapted to show the selected area with the selected resolution on the display (9).

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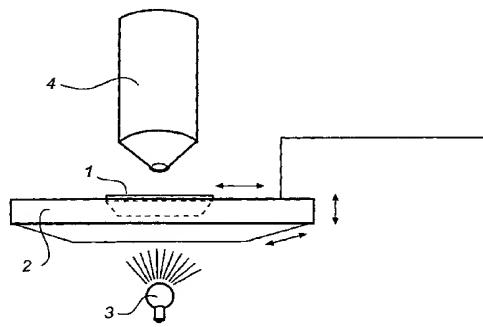
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Microscope and method for manufacturing a composite
image with a high resolution.

<u>Field of the Invention</u>

The present invention relates to a microscope with
an image sensor and a method therefor.

<u>Background Art</u>

5   For studying small structures, microscopes are gene-
rally used. There are a plurality of different microscop-
ing methods, of which the most widespread one is optical-
ly imaging microscoping. A common feature of all micro-
scopy methods is that only a limited part of the object
10   can be examined with high resolution on a separate occa-
sion. This area is usually called the field of view of
the microscope. The field of view of an optically imaging
microscope is determined among other things by the size
of the lenses in the optics. The resolution is determin-
15   ed among other things by the numerical aperture of the
optics. It is possible to achieve a large field of view
and good resolution by using large lenses with a short
focal length. However, it is extremely expensive to pro-
duce to large lenses, especially if they should also have
20   a short focal length.

As a result, it has only been possible to study
relatively small areas on a separate occasion if at the
same time high resolution is desirable.

A further problem of conventional microscoping is
25   that it is necessary to study the object through the
ocular and turn control means to move the field of view
across the object. To sit studying the object through
the ocular for a long time is tiring.

One frequently wants to study old preparations on
30   a subsequent occasion. It has then been necessary to file
the preparations and put them into the microscope once
more, which however is time-consuming work. Moreover, it
is not always possible to file the preparations. This
applies in particular to preparations in vitro since the

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preparations must be dried before being stored, which may
cause a change of the preparations.

With a view to simplifying handling, it happens that
images of relevant areas of a preparation are recorded

5   and stored. It will consequently be possible to study the
areas of the images later on without having to file the
preparations. This also renders it possible to study
relevant areas of wet preparations a long time after the
recording of the images.

10 However, when the recorded images are studied, an
image of the preparation in its entirety will not be
obtained. Nor is it possible to get an idea of how diffe-
rent images of different parts of the preparations are
related to each other.

15 Thus there is a need for a microscope which simpli-
fies handling when studying a preparation on a plurality
of subsequent occasions.

Summary of the Invention

An object of the present invention is to provide a

20 microscope, which minimises the handling of preparations
in repeated studies of an individual preparation.

A further object of the present invention is to pro-
vide a microscope which is adapted to store images of an
area which is larger than the field of view of the micro-

25 scope while at the same time the relationship between
different parts of the preparation can be recovered from
the stored images.

One more object of the present invention is to pro-
vide a method for microscoping, which facilitates repeat-

30 ed studies of an individual preparation.

A further object of the present invention is to pro-
vide a memory medium with a computer program, which faci-
litates repeated studies of an individual preparation.

These objects are achieved by means of a microscope,

35 a memory medium and a method according to the appended
claims.

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A basic concept of the invention is to form a digital image with high resolution of a larger part of the object than has been possible with conventional equipment.

5   A microscope according to the invention comprises an object holder, a display, optics which in an image plane forms an image of an object placed in the object holder, and an image sensor for recording the image. The microscope is characterised in that it further comprises

10   a storage means, an input means for selecting an area in the composite image and a resolution in the selected area, and a calculation means which is connected to the image sensor and which is adapted to digitally store in the storage means at least two recorded images, each of

15   the images partly overlapping at least one further image, to join the at least two recorded images so that the composite image is an image of the area which was reproduced on the at least two recorded images, and to store in the storage means information about the position of the

20   recorded images in the composite image. The calculation means is further adapted to show the selected area with the selected resolution on the display.

By the microscope being adapted to form a digital image of a plurality of partial images, it is possible

25   to later on study an optional area of the image without the preparation needing to be available.

By joining the recorded images is meant that the pixels in the recorded images are given positions in a common system of coordinates.

30   Preferably, the calculation means is adapted to store in the storage means the composite image, but alternatively each of the recorded images can be given a position which is stored in the storage means, the pixels obtaining a common system of coordinates.

35   According to one aspect of the present invention, a computer-readable memory medium is provided, on which a computer program is stored, which is adapted to be used

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for storing digital images which have been recorded with
an image sensor. The computer program comprises instruc-
tions for making the computer read an input signal which
represents at least two digital images, to join the digi-
5　tal images to obtain a composite image of the area which
is reproduced on the at least two digital images, to read
information which defines an area and a resolution for
the area in the composite image, and to output a digital
output signal which represents the selected area with the
10　selected resolution.

　　　It is advantageous to record the partial images with
the highest resolution allowed by the optics since the
greatest possible freedom of action will then be obtained
when later studying the composite image.

15　　　Preferably the calculation means is adapted to con-
trol the object holder. The calculation means moves the
object holder between each recording of a new image and
stores at least two recorded images in the storage means.
The displacement is adjusted so that the recorded images
20　partly overlap each other.

　　　It is advantageous to record the position of the
object holder together with the recorded image since such
a position can be used when the images are put together.
The position of the object holder is obtained from e.g.
25　stepping motors which are used to move the object holder.

　　　According to a less preferred embodiment, the object
holder is moved manually. The calculation means is then
adapted to receive an input signal with information about
the relationship between the recorded images so that it
30　can join the images in the correct manner. Manual preci-
sion displacement of the object holder, however, is very
time-consuming, and therefore automatic displacement is
preferred.

　　　The joining of the images can be carried out in
35　various ways. According to a preferred embodiment of the
invention, the calculation means is adapted to join two
recorded images by moving the images in relation to each

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other so that an edge area of one image is fitted to an
edge area of the other image, said edge areas overlapping
each other. Consequently, high precision in the motion of
the object holder is not necessary, which makes it

5   possible to use a simpler and, thus, less expensive
object holder.
     The recorded images are stored either as black-and-
white images or colour images. In both cases, each pixel
is associated with at least one value which describes

10   colour or luminous intensity. It has been found advanta-
geous to fit the edge areas to each other by minimising
the sum of squares of the difference between a value for
each of the pixels in one edge area and the value of the
overlapping pixel in the other edge area. The calculation

15   is carried out for at least two different relative posi-
tions between the images, whereupon the position which
yields the smallest sum of squares is selected as the
correct position.
     To minimise the calculation work when the images are

20   to be fitted to each other, it has been found advanta-
geous to carry out the fitting of two images in at least
two steps, the resolution for the edge areas increasing
for each step. As a starting point for the fitting, use
is made of approximate positions which have been recorded

25   with the images. The resolution of the recorded image is
reduced digitally, whereupon the images are fitted toge-
ther. The square of the differences between the pixels is
summed up with the images in at least two different rela-
tive positions. Subsequently, a higher resolution is

30   used, whereupon the fitting-together is repeated for this
higher resolution. The optimal position from the first
fitting-together is used as a starting point for the
second fitting-together.
     To further minimise the calculation work, it has

35   been found advantageous to spatially filter the images
before putting them together. This means that the effect
of, for example, grains of dust which only appear on one

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of the images, is minimised. The filtering improves the
possibilities of minimising the sum of squares by mini-
mising the sum of squares in one direction at a time.
Minimising the sum of squares in one direction at a time
5   reduces the calculation work compared with the case where
the sum of squares is calculated for all possible rela-
tive positions in a predetermined number of pixels from
the starting position. However, with unfiltered images
it is not always possible to obtain the minimum sum of
10   squares by minimising the sum of squares in one direction
at a time.

      When the images are stored as colour images, the
difference between two pixels can be defined as the
sum of the differences for each of the colour compo-
15   nents included. Alternatively, the difference between
two pixels can be defined as the difference between the
intensity values of one of the colours included.

      The put-together image has areas that are present
in more than one of the recorded images. The value of the
20   pixels in the put-together image is advantageously an
interpolation between the value of corresponding pixels
in the recorded images, the value of each of the pixels
being weighted in relation to how close to the edge of
the respective images they are located. Thus, pixels
25   located far away from the edge are suitably taken into
greater consideration than corresponding pixels located
close to the edge of another recorded image.

      According to one aspect of the present invention,
the calculation means is adapted to select edge areas
30   having high spatial frequencies and a high contrast and
to join the recorded images by fitting-together the
selected edge areas. By selecting edge areas with high
spatial frequencies and a good contrast, a good fitting-
together is obtained while at the same time the calcula-
35   tion work is minimised.

      When more than two images are to be put together,
there are a plurality of possible orders in which the

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images are put together. It is then advantageous for the
microscope to be adapted to recognise high spatial fre-
quencies with a high contrast in the edge areas and to
put together pairs of the recorded images in an order
5   determined by the spatial frequencies and the contrast
at the edge of the images. Thus, the composite image is
increased by a recorded image in each step. Consequently
not all edges between the different images are adjusted
in the composite image. This gives the advantage that the
10   result in the composite image will be less sensitive to
structureless areas in the edge area of an image.

        Of course, it is possible within the scope of the
invention to adjust all edges between all recorded images
at the same time. However, extensive calculations are
15   necessary to achieve simultaneous adjustment of all
recorded images.

        If all images are to be adjusted to each other at
the same time it is, however, advantageous to calculate
a comparative value for a plurality of different relative
20   positions for each pair of adjoining images, the compa-
rative value being a measure of how well the edge areas
correspond to each other, and subsequently put together
the recorded images in relative positions, so that a
weighted sum of the comparative values for the pairs of
25   images is maximised.

        By this method, the calculation work is minimised
while at the same time a better total fitting-together
of the images is obtained. By weighted sum is meant that
the different comparative values are weighted according
30   to how reliable they are.

        It has been found advantageous that the comparative
values are based on the covariance of the areas where
the images overlap each other for a number of different
relative positions between the images.

35   In order to further reduce the calculation work, it
is advantageous for the comparative values to be calcu-
lated for displacements of the images in two orthogonal

directions, the images being projected onto rows and columns respectively in the images before the comparative values are calculated.

By calculating comparative values for one direction at a time, the calculation work is significantly reduced. Projection of the images implies that the intensity values in the rows and columns respectively are added up.

It has also been found advantageous to calculate the sum of the comparative values in each of two orthogonal directions at a time. This significantly reduces the calculation work.

Each of the pixels has at least one intensity value. Preferably the calculation of comparative values is carried out by calculating the covariance of the overlapping areas.

When putting together images and calculating comparative values, it is advantageous to carry out the calculations at a gradually increasing resolution. In a first step, images having a lower resolution are then generated digitally, starting from the recorded images. This reduces the calculation work.

After putting together the images, a total image is obtained which reflects the entire recorded area.

It goes without saying that the above features can be combined in the same embodiment.

With a view to further elucidating the invention, detailed embodiments of the invention will be described below without, however, the invention being considered to be restricted thereto.

Brief Description of the Drawings

Fig. 1 illustrates a microscope according to a preferred embodiment of the present invention.

Fig. 2 is a flow chart of the method according to a preferred embodiment of the present invention.

Fig. 3 is a schematic view of images recorded by means of a microscope according to an embodiment of the present invention.

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Fig. 4 shows two images recorded by means of a microscope according to an embodiment of the present invention.

Detailed Description of the Invention

5   Fig. 1 illustrates a microscope according to a pre-
ferred embodiment of the present invention. An object 1
is placed on a movable object holder 2 and illuminated
from below by a bulb 3. An objective 4 images the object
on a CCD 5 which has a number of image elements 6 at
10   a mutual centre distance D. The CCD 5 is intended for
recording of images and is connected to a calculation
means 7 which in this case is a computer 8 with a display
9 and an input means 10 in the form of a keyboard and a
mouse. Moreover, the computer is connected to and can
15   control the object holder 2.

A user of the microscope initiates recording of an
image of the object 1. In the initiation, a user inputs
via the input means 10 information about how the image is
to be recorded, i.e. the desired size of it, the desired
20   resolution and how the object holder is to be arranged in
relation to the objective at the beginning of the record-
ing. The object 1 is, for example, a specimen of white
blood cells which is to be studied in the microscope. By
means of the inputted information, the microscope records
25   images that are stored in a storage means 11 in the com-
puter 8. Between each recording and storing of an image,
the computer 8 controls the object holder 2 to be moved
so as to image a new area, which partly overlaps the pre-
ceding area that has been recorded. The storage means 11
30   can be a direct access memory or a hard disk in the com-
puter 8. Thus, a number of images are recorded and stor-
ed, which correspond to the area that was defined in the
inputting via the input means 10.

Fig. 2 is a flow chart of the function of a micro-
35   scope according to a preferred embodiment of the present
invention. In step 12, information about which area is
to be studied in the microscope is inputted via the input

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means. With the aid of the inputted information, the
microscope records in step 13 a number of images which
at least partly overlap each other. In step 14, the
recorded images are put together so that a composite
5   image forms, which covers the entire area that was cover-
ed with the recorded images. In step 15, the composite
image is shown on the display 9 of the calculation means.
In step 16, a user inputs information about which area in
the shown image is to be shown at higher magnification,
10   the magnified image also being inputted in step 16. In
step 17, the selected area at the selected magnification
is shown on the display 9. Of course, the image in step
17 cannot be shown with a better resolution than that
recorded in step 13. However, in step 17 it is possible
15   to show the image at an optional magnification. According
to the preferred embodiment, the images are recorded in
step 13 with maximum resolution to allow as great freedom
of action as possible in steps 16 and 17. The image shown
in step 15 does not always reproduce the maximum resolu-
20   tion that is found in the images recorded in step 13
since the size of the display is limited.

Fig. 3 shows a number of images such as 18 and 19
that have been recorded in step 13. The edge areas are
graded in respect of high spatial frequencies and a high
25   contrast. The images recorded in step 13 are put together
to a composite image 20. When the recorded images are
put together, they are put together in pairs in an order
which is determined by how they have been graded with
respect to contrast and the presence of high special fre-
30   quencies. For example, one begins with image 18, to which
image 19 is added. When images 18 and 19 are to be join-
ed, an edge area of image 18 is compared with an image
area of image 19 so that they correspond with each other
within the area 21 in which they overlap each other. Sub-
35   sequently, the remaining images are added in an order
which is determined by which edge has the best contrast
and the greatest presence of high spatial frequencies.

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When all registered images have been put together, the
composite image is shown on the display 9. A user inputs
via the input means information about which area in the
composite image 20 is to be shown at higher magnifica-
5   tion. The selected area can be, for example, the area 22,
which contains information from four recorded images. In
the areas of the composite image 20 which contain infor-
mation from more than one image, there is made in each
pixel an interpolation between the values in the pixels
10   from each of the recorded images, weighting being car-
ried out so that pixels located close to the edge of a
recorded image obtain less weight than such pixels as are
located further away from the edge of another image.

     Fig. 4 shows two images 23 and 24 which have been
15   recorded in step 13. With reference to Fig. 4, the put-
ting-together of two recorded images will now be describ-
ed in more detail. Images 23 and 24 have been recorded
with a certain overlap and their fitting-together is car-
ried out by making a comparison within an area 25 so that
20   correspondence is obtained between the two images in the
area 25. By means of the computer 8, the area 25 is
selected, in which there is a great presence of high
special frequencies and a high contrast. In the area 25
there are structures that are to be found on both images,
25   such as the structures 26 on the image 23 and the struc-
tures 27 on the image 24. The resolution in the images
23, 24 is reduced electronically by a factor 8, so that
the number of pixels in the images is reduced by a factor
64. The image 24 is then moved in relation to the image
30   23 so that the sum of squares of the differences between
the value in one pixel in the image 23 in the area 25 and
the overlapping pixel in the image 24 in the area 25 is
minimised. The sum of squares of the differences is in
most cases minimal when the image 24 has been moved so
35   that the structures 26 have the same position as the
structures 27. Then the minimising is repeated for a gra-
dually increasing resolution when the obtained relative

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position is used as a starting position for the next
minimising step. The resolution is increased by a factor
2 in each minimising step until the maximum resolution
has been achieved. As a result, the images are placed

5   gradually closer to their correct relative position. In
each minimising step, the images are moved to different
positions, which represent a combination of the orthogo-
nal displacements from the starting position. The image
23 is composed of a number of pixels which are each asso-

10   ciated with a value describing the luminous intensity of
the pixel. If the image 23 is a colour image, it is asso-
ciated with three different colours, red, green and blue,
which each have a value describing the intensity of pre-
cisely that colour in the pixel. If the images are colour

15   images, the comparison is made in the edge area between
each of the colours or between a converted image, in
which case the converted image is a grey-scale image of
the original colour image. It is also possible to use
only one of the colours when comparing the images.

20   With reference to Fig. 3, an alternative method of
putting together the images will now be described. First
the optimal fitting between each pair of images 18, 19
is determined. The fitting-together of two images is
carried out by calculating the covariance of the area

25   within which the images overlap each other for a plura-
lity of different relative positions between the images
18, 19. The covariance is used as a comparative value to
find the best fitting-together of the images. Before cal-
culating the covariance, a projection of the images is

30   made onto each of two orthogonal directions in the
images. Thus, the rows and the columns respectively are
added up, after which the covariance is calculated in the
direction of the columns and rows respectively for a num-
ber of different relative positions. The covariance is

35   calculated in the usual fashion except that no dividing
by the number of measuring points occurs. For each of the
pairs of images a set of covariances is obtained as a

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function of the displacement. In each of the sets con-
taining covariances for different displacements, its
maxima are searched out. This point and two adjoining
points are used to form a curve of the second degree,
which together with the corresponding curves of the
second degree for the other sets is used to put together
all the recorded images. When fitting together the pairs
of images, a weight W is calculated which is a measure of
how reliable the fitting-together is. The weight W is
given by:

$$W = 1 - \sum_i \left(\frac{S(i) - 0.25 * \max(S)}{0.75 * \max(S)} \right)^2 - \sum_j \left(\frac{S(j) - 0.50 * \max(S)}{0.50 * \max(S)} \right)^2$$

wherein

$$i \in \left[S(i) \geq 0.25 \max(S), |i - \max| > 2 \right] - j \in \left[S(j) \geq 0.50 \max(S), |j - \max| = 2 \right],$$

wherein S(i) is the covariance at the displacement i,
and S(max) = max(S). If W becomes negative, the fitting-
together is considered unusable and W is set at zero. If
the images are not square, it is easier to find a good
fitting-together of between the images along the long
edge. Then the fitting-together is advantageously carried
out in this direction first.

After determining the relative positions of each
pair of images, all the recorded images are put together
so that a weighted sum of the comparative values is maxi-
mised. This means that a weighted sum of the covariances
for the different pairs of images is maximised. This,
too, is made first in one of the direction of the columns
and the direction of the rows and then in the other
direction. The maximisation is carried out by minimising
the function

$$E = \sum_{l=0}^{m-1} \sum_{k=0}^{n-2} W_{l,k,1} \left(C_{l,k,0} - \left(X_{l,k} - X_{l,k+1} \right) \right)^2 + \sum_{l=0}^{m-2} \sum_{k=0}^{n-1} W_{l,k,1} \left(C_{l,k,1} - \left(X_{l,k} - X_{l+1,k} \right) \right)^2 ,$$

wherein m is the number of images in a column, n the number of images in a row, $C_{1,k,0}$ is the optimal fitting-together of image [1,k] and its right neighbour and $C_{1,k,1}$ is the optimal fitting-together of image [1,k] and its lower neighbour. $W_{1,k,0}$ and $W_{1,k,1}$ are correspondingly the weight of the respective two-image fittings. $X_{1,k}$ is the displacement of the image in the x direction or in the y direction depending on the optimisation that has been carried out.

A person skilled in the art realises that the invention is limited to the embodiments described, which can be varied within the scope of the invention. For example, the CCD can be replaced by a vidicon. Moreover the user need not necessarily initiate the recording of the partial images by specifying the size and resolution of the completed image since this can be carried out according to a predetermined schedule stored in the computer.

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CLAIMS

1. A microscope comprising
an object holder (2),
optics (4) which in an image plane forms an image
of an object (1) placed in the object holder (2),
and
an image sensor (5) for recording the image,
c h a r a c t e r i s e d in that the microscope fur-
ther comprises
a display (9),
an input means (10) for selecting an area in an
image and a resolution,
a storage means (11), and
a calculation means (8) which is connected to the
image sensor (5) and which is adapted
(i) to digitally store in the storage means at least
two recorded images, each of the recorded images compris-
ing a plurality of pixels, and each of the images partly
overlapping at least one other image,
(ii) to join the at least two recorded images so
that the composite image is an image of the area which
is reproduced on the at least two recorded images (18,
19, 23, 24), and
(iii) to store in the storage means (11) information
about the composite image, and
to show, on the display (9), the area having the
selected resolution and selected with the aid of the
input means.
2. A microscope as claimed in claim 1, c h a r -
a c t e r i s e d in that the calculation means is adapt-
ed to store the composite image in the storage means
(11).
3. A microscope as claimed in claim 1, c h a r -
a c t e r i s e d in that the calculation means is adapt-
ed to store in the storage means (11) information about

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the positions of the recorded images in the composite
image.

    4. A microscope as claimed in any one of the pre-
ceding claims, c h a r a c t e r i s e d in that the cal-
5   culation means further is adapted
        to control the motion of the object holder (2) and
        to store at least two recorded images in the storage
means (11), between which recordings the object holder
(2) has been moved so that the recorded images partly
10   overlap each other.

    5. A microscope as claimed in any one of the pre-
ceding claims, c h a r a c t e r i s e d in that the cal-
culation means (7) is adapted to receive an input signal
with information about the relationship between the
15   recorded images.

    6. A microscope as claimed in any one of the pre-
ceding claims, c h a r a c t e r i s e d in that the cal-
culation means (7) is adapted to join two recorded images
by placing the images in relation to each other so that
20   an edge area of one image is fitted to an edge area of
the other image, said edge areas overlapping each other.

    7. A microscope as claimed in any one of the preced-
ing claims, c h a r a c t e r i s e d in that the calcu-
lation means (7) is also adapted to calculate a compa-
25   rative value for a plurality of different relative posi-
tions for each pair of recorded images when they are
arranged so that an edge area of one image overlaps an
edge area of the other image, the comparative value being
a measure of how well the edge areas correspond to each
30   other, and subsequently put together the recorded images
in relative positions so that a weighted sum of the com-
parative values for the pairs of images is maximised.

    8. A microscope as claimed in claim 7, c h a r -
a c t e r i s e d in that comparative values are calcu-
35   lated for displacements of the images in two orthogonal
directions, the images being projected onto rows and

columns respectively in the images before the comparative values are calculated.

9. A microscope as claimed in claim 7 or 8, c h a r a c t e r i s e d in that the calculation of the sum of the comparative values is carried out in each of two orthogonal directions at a time.

10. A microscope as claimed in claim 7, 8 or 9, c h a r a c t e r i s e d in that each of the pixels has at least one intensity value, and that the calculation of the comparative values is carried out by calculation of the covariance of the overlapping edge areas.

11. A microscope as claimed in claim 6, c h a r - a c t e r i s e d in that each of the pixels has at least one intensity value, and that fitting-together of the edge areas results in minimising of the sum of squares of the difference between the intensity value for each of the pixels in one edge area (25) and the overlapping pixel in the other edge area.

12. A microscope as claimed in claim 6 or 11, c h a r a c t e r i s e d in that the calculation means is adapted to select, for said fitting-together, edge areas in the images with a great presence of high spatial frequencies and a high contrast.

13. A microscope as claimed in any one of claims 6, 11 or 12, c h a r a c t e r i s e d in that the calculation means is adapted

to recognise structures in the edge areas (25) and

to join the recorded images in an order determined by the spatial frequencies and the contrast at the edge of the recorded images.

14. A microscope as claimed in any one of the preceding claims, c h a r a c t e r i s e d in that the recorded images are recorded at maximum resolution of the optics (4).

15. A method for microscoping comprising the step of

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recording with an image sensor (15) at least two
images, which partly overlap each other and which have
been reproduced in a microscope,   c h a r a c t e r i s -
e d   in that it further comprises the steps of
5   joining the recorded images (18, 19, 23, 24) to
obtain a composite image of the area which is reproduced
on the at least two recorded images (18, 19, 23, 24),
          selecting an area and a resolution for the area in
the composite image, and
10   showing the selected area with the selected reso-
lution on a display (9).
          16. A method as claimed in claim 15,   c h a r a c -
t e r i s e d   in that it further comprises the steps of
          selecting on the images pairs of the edge areas
15 which overlap each other, and
          placing the edge areas in relation to each other
so that the sum of squares of the differences between
each of the pixels in the edge area of one image and the
overlapping pixel in the edge area of the other image is
20 minimised.
          17. A method as claimed in claim 15,   c h a r a c -
t e r i s e d   in that it further comprises the steps of
          selecting in pairs on the images the edge areas
which overlap each other,
25   calculating a comparative value for a plurality of
different relative positions for each pair of images when
the edge areas overlap each other, the comparative value
being a measure of how well the edge areas correspond
to each other, and
30   subsequently joining the recorded images in relative
positions so that the sum of the comparative values for
the pairs of images is minimised.
          18. A method as claimed in claim 17, characterised
in that the comparative values are calculated for dis-
35 placements of the images in two orthogonal directions,
the images being projected onto the rows and columns

respectively before the comparative values are calcu-
lated.

19. A method as claimed in claim 17 or 18,
c h a r a c t e r i s e d in that the minimising of the
sum of the comparative values is made in each of two
orthogonal directions at a time.

20. A method as claimed in claim 16, c h a r a c -
t e r i s e d in that the placing of the images, and
the associated calculation of the sum of the differences
between their pixels, are carried out in at least two
steps, the resolution in the image increasing in each
step.

21. A method as claimed in any one of claims 16-20,
c h a r a c t e r i s e d in that the recorded images are
spatially filtered before being put together.

22. A computer-readable memory medium, on which a
computer program is stored, which is intended to be used
for storing of digital images which have been recorded
with an image sensor, c h a r a c t e r i s e d in that
the computer program comprises instructions for making
the computer (8)

read an input signal which represents at least two
digital images,

join the digital images (18, 19, 23, 24) to obtain a
composite image of the area which is reproduced on the at
least two digital images (18, 19, 23, 24),

read information which defines an area and a reso-
lution for the area in the composite image, and

output a digital output signal which represents the
selected area with the selected resolution.

23. A computer-readable memory medium as claimed in
claim 22, c h a r a c t e r i s e d in that the computer
program also comprises instructions for making the compu-
ter (8)

select on the images pairs of edge areas (25) which
overlap each other, and

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place the images in relation to each other so that
the sum of the differences between each of the pixels in
the edge area of one image and the overlapping pixel in
the edge area of the other image is minimised.

5   24. A computer-readable memory medium as claimed in
claim 22, c h a r a c t e r i s e d in that the computer
program also comprises instructions for making the compu-
ter (8)

perform the placing of the images and the associated
10   calculation of the sum of the differences between their
pixels in at least two steps, the resolution in the image
increasing in each step.
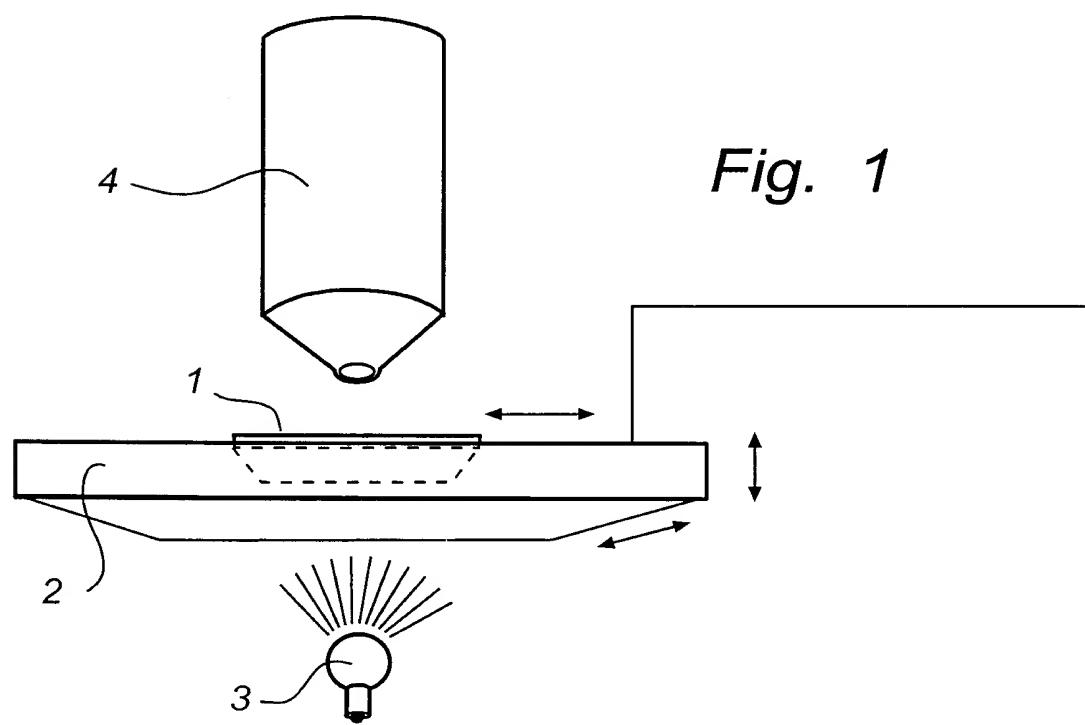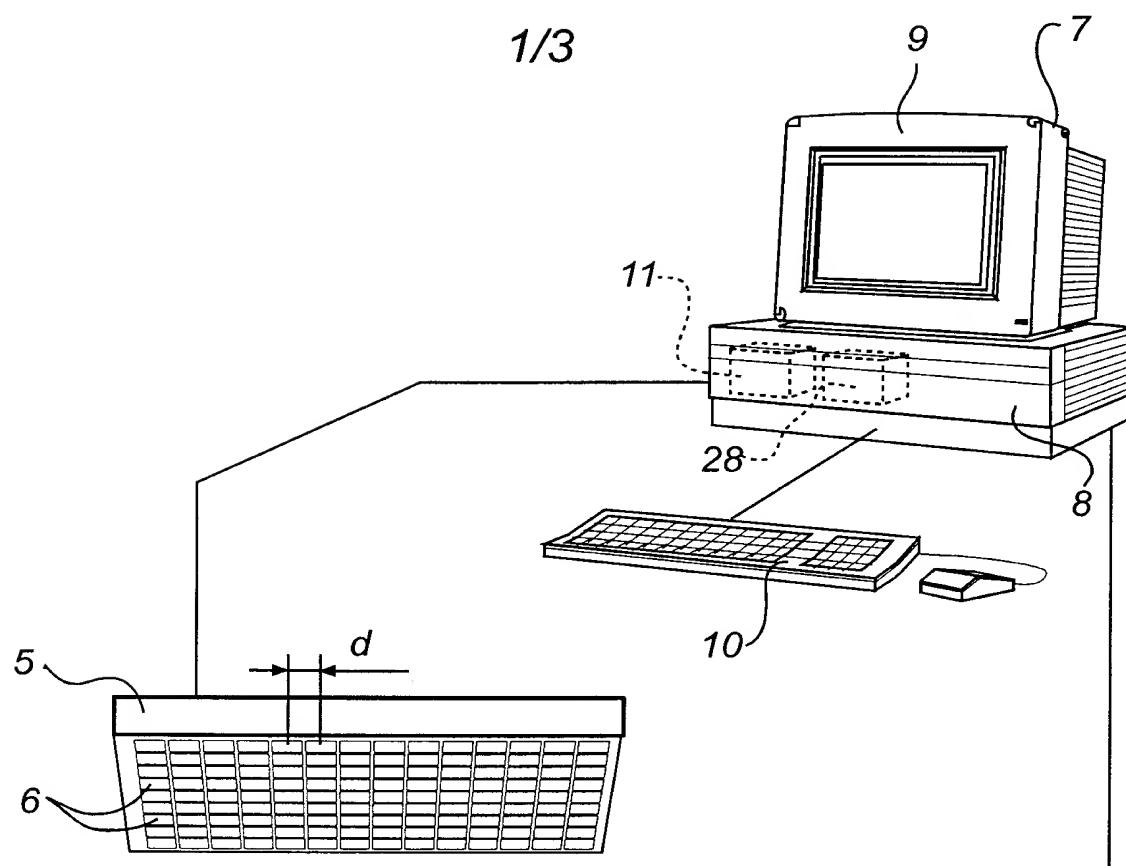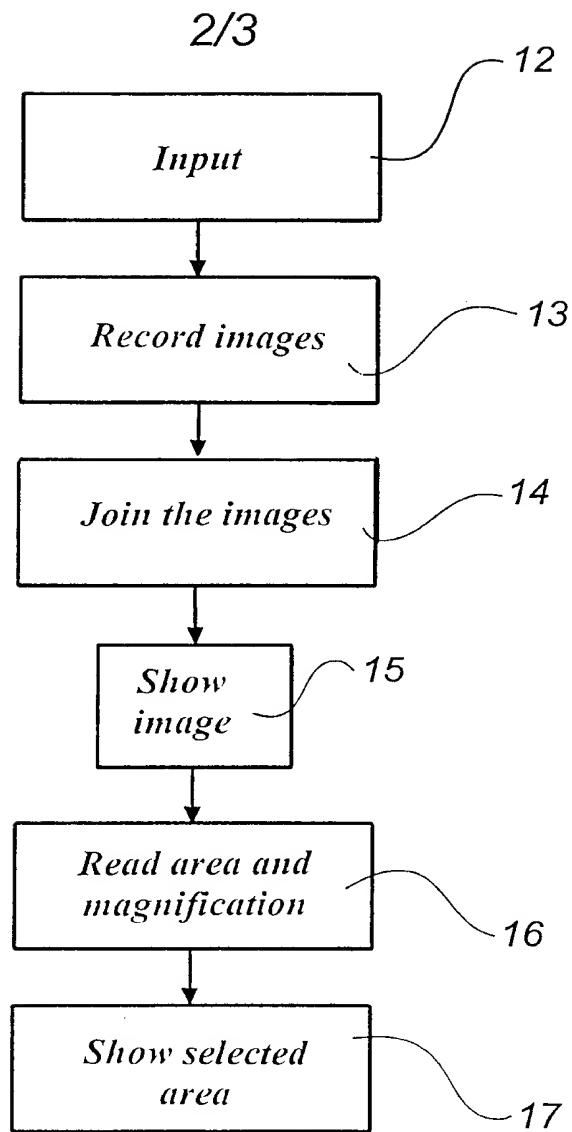
Fig. 1
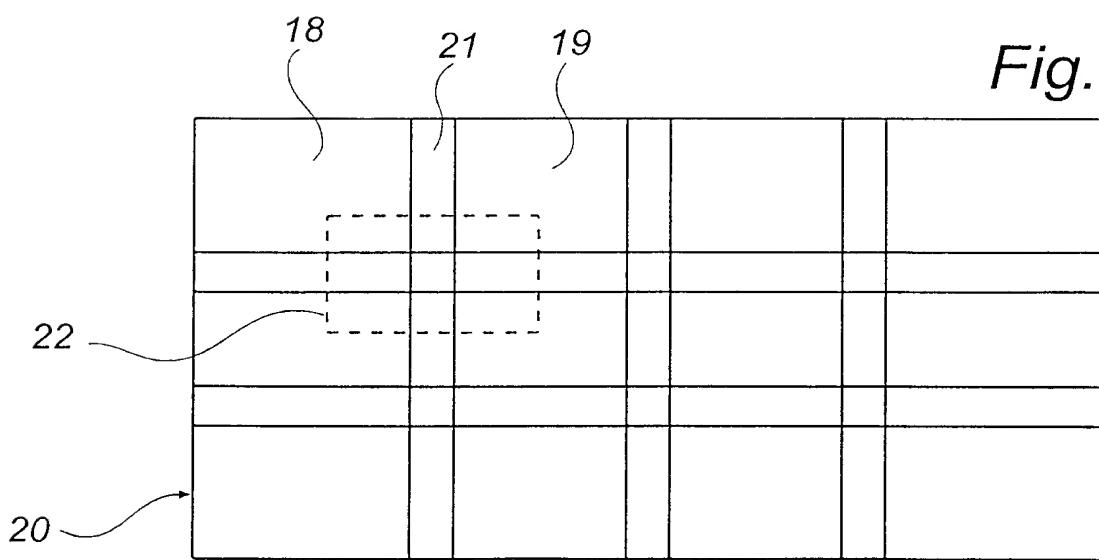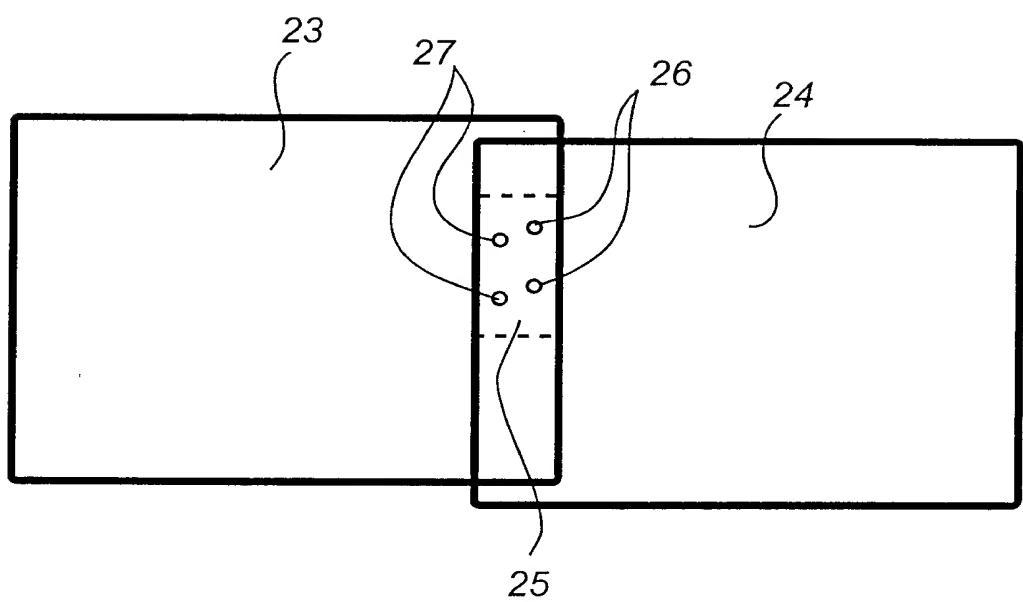
2/3

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┌─────────────────┐
│      Input      │ ── 12
└─────────────────┘
         │
         ▼
┌─────────────────┐
│  Record images  │ ── 13
└─────────────────┘
         │
         ▼
┌─────────────────┐
│ Join the images │ ── 14
└─────────────────┘
         │
         ▼
┌──────────────┐
│     Show     │ ── 15
│    image     │
└──────────────┘
         │
         ▼
┌─────────────────┐
│  Read area and  │
│  magnification  │ ── 16
└─────────────────┘
         │
         ▼
┌─────────────────┐
│  Show selected  │
│      area       │ ── 17
└─────────────────┘
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Fig. 2

Fig. 3

Fig. 4

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G02B 21/00 // H04N 1/387

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G02B, H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0731371 A1 (PERKIN-ELMER LIMITED), 11 Sept 1996 (11.09.96), column 1, line 54 – column 2, line 44; column 3, line 13 – column 6, line 47, figures 1,5	1-18
A	US 4673988 A (P.A. JANSSON ET AL), 16 June 1987 (16.06.87), figure 1, abstract	1-18
A	US 4202037 A (E.M. GLASER ET AL), 6 May 1980 (06.05.80), figure 1, abstract	1-18
A	US 5452105 A (A. TAMAGAKI ET AL), 19 Sept 1995 (19.09.95), figures 9,10,14, abstract	1-18

| X | Further documents are listed in the continuation of Box C. | X | See patent family annex. |

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 February 2001	0 5 -02- 2001
Name and mailing address of the ISA/ **Swedish Patent Office** Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Patrik Blidefalk/mj Telephone No. + 46 8 782 25 00

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C (Continuation).   DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9809434 A1 (BEIJING JINRUIYA TACHNOLOGY DEVELOPMENT CO., LTD.), 5 March 1998 (05.03.98), figures 9,10,14, abstract	1-18

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INTERNATIONAL SEARCH REPORT

Information on patent family members

27/12/00

International application No.

PCT/SE 00/01996

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